2023 Boston Speech Motor Control Symposium #2023BSMCS

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Detection and Classification of Nasality Using Spectral Analysis of Only the Nasal Speech Signal

F. Abnavi, H. Flowers, H. Dajani, S. Ahn, T. Bressmann

Background: Accurate detection and classification of nasality disorders are key to the treatment of children with cleft palate. However, the acoustic classification of nasality based on single microphone recordings has proven difficult. The current study attempted to detect and classify nasality disorders using recordings of the nasal speech signal alone.
Methods: Eleven typical female speakers were recorded with a Nasometer headset. They produced a nasal and a non-nasal sentence while simulating hyper-, hypo-, and mixed nasality. Voice low-to-high tone ratios (VLHR) with cut-off frequencies of 700Hz and 2500Hz and the spectral amplitude of 1/3 octave frequency bands at 630Hz, 800Hz, and 1000Hz were calculated from the nasal signal. The spectral band variables were entered into "oralance" formulas of the form: (nasal band energy for the non-nasal sentence/ (combined nasal band energy for the nasal + non-nasal sentences)) *100. The VLHR variables were also entered into cognate formulas. Linear discriminant analysis (LDA) was carried out to create a classification algorithm based on the five spectral ratios.
Results: The LDA function based on the five spectral oralance ratios of the nasal signal classified simulated hyper-, hypo-, mixed nasality, and normal resonance with 96% accuracy. One of 22 hyponasal samples was misclassified as mixed, one of 22 hypernasal samples as normal, and one of 22 mixed samples as hypernasal.
Conclusion: The discriminant analysis of the spectral features of the nasal-only signal had high classification accuracy. In the next step, the method will be evaluated with clinical samples.

Key Words: spectral analysis; nasal speech signal; nasality

Pitch and Formant Targets Vary Across Days as Seen in Reflexive Responses to Auditory Perturbations

A. Acosta, E. Kearney, F. Guenther

Several leading models of speech production assume the existence of internal targets for acoustic parameters like fo and formant frequencies, and numerous past experiments provide evidence for such targets in the form of reflexive compensatory responses to unpredictable perturbations of acoustic feedback during speech. Although these targets are typically assumed to remain unchanged from day to day in a fully developed adult, evidence for this assumption is lacking. The goal of the present study was to investigate this issue by analyzing reflexive responses to auditory perturbations over multiple sessions on different days. 24 native speakers of American English participated in four sessions over 4-10 days consisting of unpredictable fo and F1 perturbations applied to steady state vowel productions. Baseline fo and F1 values (measured during unperturbed vowel production) varied significantly across sessions for nearly all speakers. Furthermore, reflexive compensatory responses were always in the direction of the current session's baseline; in other words, corrective responses were aimed at different fo and F1 targets in different sessions.These results imply that, even for a native adult speaker, auditory targets for pitch and formant frequencies vary over time. This result is less surprising for fo since an individual's baseline fo does not affect speech perception. In contrast, formant frequencies strongly affect vowel perception. The finding that F1 targets vary over time is thus surprising and suggests that an individual's internal auditory targets for self-produced vowels are not specific formant frequencies but instead more abstract aspects of the acoustic signal.

Key Words: Auditory perturbations; targets; pitch

Voluntary Elimination of Nasality Using Forward Voice Focus and Visual Biofeedback

S. Al-Ees, T. Bressmann

Speakers have limited proprioception of velopharyngeal movement. This makes it challenging to attain voluntary velopharyngeal closure in speech therapy of hypernasal speakers with cleft palate. In our previous studies, select individuals reduced nasalance scores with forward voice focus. The present study used forward voice focus and visual biofeedback to eliminate nasality in connected speech.
Ten typical speakers (9 F; mean age 25 yrs) used forward voice focus combined with visual biofeedback from a Nasometer to eliminate nasality from their connected speech in 7 steps: 1. Baseline, 2. visual biofeedback, 3. forward voice focus with biofeedback, 4. reduced nasality with forward focus and biofeedback, 5. reduced nasality with biofeedback, 6. reduced nasality without biofeedback, and 7. after a washout. Nasalance scores for 4 nasal carryover sentences were recorded in baseline, reduced nasality without biofeedback, and after washout conditions.
Nasalance scores for carryover sentences dropped from 59.99 (SD 7.85) at baseline, to 32 (SD 15.7) in the final recording without biofeedback, and to 28 (SD 14.75) after washout. A repeated-measures ANOVA showed a significant effect of condition, $F(2,18)=49.06$, $p<0.001$. Post hoc Bonferroni tests showed that nasalance scores in the final recordings without biofeedback and after washout conditions were significantly lower than baseline (both $p<0.05$).
Speakers could lower nasalance scores in forward voice focus with visual biofeedback. Reduction of nasopharyngeal lumen in forward voice focus may have facilitated voluntary velopharyngeal closure. Participants maintained reduced nasality without biofeedback and after washout. The technique should be explored with hypernasal speakers with cleft palate.

Key Words: nasality, voice focus, biofeedback

Implicit and Explicit Motor Sequence Learning in Adults With Developmental Language Disorder

S. Bartolo, S. Banel, G. J. Cler

Developmental language disorder (DLD) is a neurodevelopmental disorder that impacts approximately 7% of the population, and is characterized by unexplained deficits in expressive and/or receptive components of language. Research involving non-speech motor sequence learning has led to models of the behavioral and neurobiological bases of DLD. The procedural deficit hypothesis suggests that individuals with DLD possess deficits in all procedural learning and memory, while the sequential pattern learning deficit hypothesis proposes that only sequence-based procedural memory and learning is impaired.
A common procedural learning task used to develop these models is the serial reaction time (SRT) task. Various paradigms involve differing levels of implicit and explicit learning during this task, muddying interpretations of the data. Here, 49 participants (24 with DLD; 25 with typical language) completed implicit and explicit SRT tasks, measuring their ability to learn visually-presented, 10-element sequences. We hypothesized that adults with DLD would demonstrate reduced learning on both SRTs; we especially anticipated much less learning on the implicit SRT, as the procedural deficit hypothesis proposes intact declarative (explicit) mechanisms. Instead, we found that adults with DLD showed the same learning as adults with typical language on both SRT tasks. Adults with DLD showed increased errors, indicating deficits in mapping the visual cue to a motor response, rather than sequence learning itself. Interestingly, the DLD group also had significantly worse recall of the explicitly-learned sequence, after immediate correct verbal recall and cued performance. Results may indicate the need for additional considerations in neurobiological models of DLD.

Key Words: sequence learning, developmental language disorder, adults, motor learning

Integrity of the Corollary-Discharge Circuit for Speech in Aphasia: Neural Responses and Functional Consequences After Left-Hemisphere Stroke

S. D. Beach, S. Kiran, C. A. Niziolek

Sensory cortex is primed to expect the consequences of our actions, such as the sound of our own speech, via corollary discharge of motor commands. These predictions modulate auditory cortex, commonly causing suppression of the response to speaking in comparison to listening to the same stimulus. We previously showed that this speaking-induced suppression (SIS) may have functional consequences for speech error detection and correction, as its magnitude varies with the typicality of the utterance. Characteristically, the speech of persons with aphasia (PWA) is more errorful and acoustically variable. However, it is unknown whether SIS is robust to damage in left-hemisphere motor and auditory regions. Here we investigate the relationships among speech variability, surviving neural architecture, and corollary discharge for speech as indexed by SIS. We recorded magnetoencephalography while 15 PWA and matched controls spoke monosyllabic words and listened to playback of their utterances. In each hemisphere, we measured SIS, the difference in the amplitude of the peak evoked response between listening and speaking, and related it to lesion volume and percent tissue spared in anatomical regions of interest in PWA, and to speech variability in all participants. Preliminary results indicate that, in many cases, SIS is maintained despite large lesions. Together, these data describe the integrity of the corollary-discharge circuit, lending insight into the conditions under which PWA are able to process variation in their own speech.

Key Words: aphasia; corollary discharge; MEG

Single Case Experimental Clinical Validation of an Artificial-Intelligence-Augmented Speech Therapy for /ɹ/

N. R. Benway, J. L. Preston

For children with speech sound disorders, including speech sound disorders impacting the American English rhotic /ɹ/, at least 5,000 effective practice trials may be needed to generalize a new speech motor plan to continuous speech. However, achieving this sum, as well as the recommended frequency of practice sessions, may be hindered by service delivery barriers that create a gap between evidence-based intervention intensity and the intensity of services available clinically. Speech technologies automating clinically-validated evidence-based practices are well suited to confront these barriers. Therefore, this multiple baseline clinical trial with five replications examines participant improvement on untreated words after 10 sessions of an adaptive motor-based speech therapy during which < 10 minutes of prepractice was led by a clinician and 25 minutes of practice trial selection, practice difficulty, and knowledge of results/knowledge of performance feedback was driven by a mispronunciation detection algorithm predicting clinician judgment of the target /ɹ/ in the word. Mispronunciation detection was performed by a gated recurrent unit neural network that achieved a mean participant-specific F1-score =.81 (σx=.10, med = .83, n = 48 participants) in lab testing and lab replication. Data collection for both phases of this project has completed and data analysis will conclude within the next month. Preliminary results suggest that at least two of the three participants in the first wave of data collection demonstrated statistically significant pre-to-post improvement in average masked expert listener rating of /ɹ/ accuracy in untreated words.

Key Words: speech sound disorders, motor learning intervention, mispronunciation detection

Basal Ganglia Intracranial Local Field Potential Beta and Gamma Dynamics During Speech Production

L. Bullock, A. Bush, R. M. Richardson, F. H. Guenther

The basal ganglia's (BG) specific role in motor control is contentious, with different models foregrounding different aspects of motor control: action selection, sequencing, automation, vigor, and learning, to name a few. The BG's role in

speech motor control is even more poorly understood. Intracranial recordings of the BG are rare, but are indicated in specific clinical settings like deep brain stimulation implant surgery. These recordings can provide valuable glimpses of BG speech physiology. Previous studies have reported local field potentials (LFPs) and single-units during simple speech-like tasks, like vowel production, CVC production, and repetition of nonword syllables. Single-unit data reveal that generally around half of motor STN units are task-responsive. Most of the task-responsive units increase in firing rate at speech onset. LFPs from STN show robust beta-band (12-30 Hz) suppression before and during articulation. In this project, we report simultaneous LFP and single-unit STN and globus pallidus (GP) recordings from Parkinson's and dystonia patients during cued sentence production to determine if previous single-word production findings generalize to phrasal speech. Preliminary analyses reveal that beta power is indeed suppressed during the entirety of the utterance in STN. Broadband high-gamma (HG; 70-150 Hz) power increases prior to speech onset in STN, while it coincides with speech onset in GP. Planned analyses will differentiate how HG fluctuates at the single-trial level in GP; we hypothesize that HG power will be tuned to either the rising or falling edge of the speech acoustic envelope, indexing the release or completion of speech motor commands, respectively.

Key Words: basal ganglia; intracranial electroencephalography

The Relationship Between Speaking Rate and Age Across Different Speaking Tasks in Young Children

M. Camelio, A. Sims, P. Lynn, L. Matachun, O. Sabino, S. Sackey, K. Allison

Speaking rate has been shown to increase over the course of development in young children; however, information about the development of flexibility in speaking rate, or the ability to adjust rate in response to task demands, is lacking. The goals of this study were to 1) compare associations between speaking rate and age in four different speaking tasks: sentence repetition, counting to 10, diadochokinesis (DDK), and spontaneous speech; 2) determine whether children's range of speaking rate across tasks is associated with age or speech intelligibility. Twenty-seven children with typical development between 3-6 years of age participated in this study. We measured children's speaking rate in syllables per second for each task. Preliminary results showed that speaking rate in the counting task was most strongly associated with age ($r = .53$, $p < .01$), followed by rate in a sentence repetition task ($r = .38$, $p < .05$). DDK rate was not significantly associated with age. Speaking rate measurements from spontaneous speech samples are currently being conducted, and results of final analyses will be included in this presentation. These data demonstrate that the relationship between age and speaking rate varies across different types of speaking tasks, illustrating interactions between development and effects of task demands on speaking rate. Better understanding how typical speaking rate development is influenced by task demands is important in determining the value of certain tasks for differentiating disordered speech from typical speech.

Key Words: speaking rate; speech development

Predictors of Response to L2 Tone Training With and Without Biofeedback

X. Chen, J. J. Chung, J. Yang, C. B. Chang, T. McAllister

For adult speakers, learning to produce phonemic contrasts in a second language (L2) can be a lengthy and difficult process. Speakers of non-tone languages such as English may find it particularly challenging to learn to use vocal pitch to signal meaningful contrasts in tone languages such as Mandarin. Previous research has suggested that technology for visual-acoustic biofeedback (i.e., a real-time display of the acoustic signal of speech) can be beneficial in speech production training for L2 learners as well as clinical populations. It is also known that learners' baseline aptitudes can interact with their learning outcomes under different training paradigms. In this study, sixty-five female native English speakers without previous knowledge of Mandarin received fifty minutes of Mandarin tone production training, randomly assigned to feature a traditional imitation method or visual-acoustic biofeedback using CSL Real-Time Pitch software.

Participants also completed baseline measures of phonological awareness and perceptual acuity for pitch. Data collection from participants is complete and ratings of tone production accuracy are currently being collected from blinded native speakers of Mandarin. Linear mixed-effects models will be used to evaluate (a) whether change in perceptually rated accuracy from pre- to post-training differs between the traditional and biofeedback conditions, and (b) whether there is any interaction between treatment condition and performance on the baseline measure of pitch perception ability. Based on previous literature, we hypothesize that learners with high perceptual acuity will show progress in both treatment conditions, while low-acuity learners may show progress only in the biofeedback treatment condition.

Key Words: biofeedback; fundamental frequency; speech production training

Effects of Elicitation Modality on Novel Sound Sequence Learning

H. S. Cheng, A. Buchwald

Previous studies have demonstrated that speakers can improve their production of novel sound sequences (e.g., /gd/ in GDEEMOO; Cheng & Buchwald, 2021), but the amount of improvement varies widely across individuals. These studies have elicited speech in response to auditory and orthographic models, but it is widely known that listeners have trouble perceiving non-native sequences such as consonant clusters. We asked whether learning to produce non-native clusters is impacted by the presence of the auditory model by comparing one group of learners whose production is elicited following both auditory and orthographic models (i.e., AudOrth) to the other group following orthographic model only (i.e., OrthOnly) during training. If the difficulty in veridically perceiving the auditory model limits production learning, then participants in the AudOrth condition should exhibit less improvement than OrthOnly condition. Preliminary data (n = 14 per condition) suggest a differentiation between production accuracy as a binary measure and the extent of coordination between the consonants in the cluster. Particularly, the improvement in cluster accuracy was higher in the AudOrth group than in the OrthOnly group, suggesting that the absence of the acoustic model may hinder accuracy. However, the OrthOnly group showed more cluster-like coordination between the two consonants (measured in the acoustic record), suggesting that the acoustic model may not benefit all aspects of cluster learning. Overall, these results will shed light on how learning to produce novel sound sequence is impacted by perceptual factors.

Key Words: novel sound sequence learning, elicitation modality, production-perception relationship

Acoustic and Laryngoscopic Investigation Into Laryngeal Tension in Patients With Unilateral Vocal Fold Hypomobility

H. N. Doerr, S. A. Mazloum, J. M. Vojtech, V. S. McKenna

Background: Unilateral vocal fold hypomobility (UVFH) is a nerve-based voice problem in which one vocal fold moves asynchronously or asymmetrically to the other. People with UVFH often exhibit hyperfunctional vocal behaviors—such as supraglottic constriction—to compensate for poor glottal closure. A non-invasive measure of hyperfunction is relative fundamental frequency (RFF), but this measure has not been investigated as a clinical indicator of hyperfunction in this patient population. Therefore, this project evaluated the relationship between RFF and the degree of supraglottic constriction in people with UVFH.
Method: Participants were prospectively enrolled from the University of Cincinnati and included adults diagnosed with UVFH by a laryngologist. Video images of supraglottic constriction were captured via halogen-based flexible nasendoscopy during sustained /i/ productions. Still images were rated separately for mediolateral compression (affected and unaffected side) and anteroposterior constriction using the Voice-Vibratory Assessment with Laryngeal Imaging rating system. RFF was extracted from utterances of /ɑfɑ, ifi, ufu/ via a semi-automated algorithm.
Results: Recruitment for this study is ongoing. We have enrolled 2 participants so far out of a target of 15 participants. Statistical analysis will include regression analyses between constriction ratings and RFF values (offset 10 and onset 1).

Conclusion: Although UVFH is associated with secondary hyperfunction, measures of hyperfunction in this population are limited. This study is the first to assess the utility of RFF for non-invasively assessing hyperfunction in UVFH, adding to our understanding of whether RFF could quantify tension in those with UVFH.

Key Words: voice; acoustics; laryngoscopy

A Landmark-Based Account of the Temporal Organization of Speech Kinematics

S. K. Harper, E. F. Chang

The integration of articulatory gestures encoding (sub)segmental phonological information into larger coordinative structures is critical for speech production. Previous research on the temporal organization of speech kinematics has largely focused on the precise control of movement execution timing. However, the mechanisms governing the organization of speech kinematics into the higher-order temporal structures likely to be critical for speech planning and execution remain largely unknown.
In this study, we demonstrate that the temporal organization of speech kinematics can be characterized through their relationship to syllable-level speech landmarks. Kinematic and acoustic data from eight speakers in the Haskins Rate Production Comparison Database were used to examine the relationship between speech kinematics and a set of systems that have been previously proposed as motor planning units for speech production: the jaw cycle, the acoustic speech envelope, and levels of the symbolic linguistic hierarchy ranging from the phoneme to the word.
Joint Recurrence Quantification Analyses of the data demonstrate a general tendency for speech kinematics to couple with events with a similar frequency of occurrence as syllables. Speech kinematics exhibited the strongest and most consistent organization around acoustic onset edges in the speech envelope, a temporal landmark that has been identified in previous work as a perceptually critical acoustic marker for syllables. Additional analyses indicate that this landmark is aligned to the maximum velocity of vocal tract opening in articulation. Together, this suggests that speech kinematics exhibit recurrent temporal structure at the level of the syllable, specifically organizing around a syllable-level articulatory-acoustic landmark.

Key Words: speech kinematics; temporal organization; landmarks

Relationships Between Speech Acoustics and Speech Intelligibility in Monosyllabic Words in Adults With Down Syndrome and Healthy Speakers in Persian

N. Khaloueipour, K. Reilly

The present study investigates whether changes in speech acoustics associated with Down syndrome (DS) have language-specific effects on speech intelligibility. Previous research has found that vowel formant variability is a sensitive predictor of single-word intelligibility in speakers with DS (Carl et al., 2020) as well as other motor speech populations (Kim et al., 2011). These findings may not be true for speakers of languages with less crowded vowel spaces such as Persian.
Participants are 13 Persian speakers with DS and 20 healthy Persian speakers. Stimuli consisted of 36 monosyllabic CVC syllables containing pairwise combinations of Persian stop consonants and Persian vowels. Vowel productions are characterized by their F1 and F2 frequencies, which are used to derive each speaker's vowel space area and intra-vowel formant variability. Voice onset times and formant transitions are derived to evaluate speakers' encoding of voicing and place of articulation distinctions for stop consonants. Formant transitions are characterized in terms of direction, transition extent, transition rate and transition duration.
Single-word intelligibility is evaluated by five Persian listeners who provide an orthographic transcript for each speech utterance and record a score indicating the certainty of their judgment.
To date, speech acoustic analyses have been completed for all vowel and consonant features. The intelligibility portion of the experiment is underway and, when complete, correlations will identify associations between one or more acoustic

features single-word intelligibility. These findings are expected to elaborate whether/how the size of a language's phoneme inventory affects the relationship between speech acoustics and speech intelligibility.

Key Words: Down syndrome, Speech Acoustics, Speech Intelligibility

Effects of Anti-Chorea Therapy on Speech in Huntington's Disease

D. Kim, A. Mefferd, K. R. Hay, S. Shiino, C. Raines, M. de Riesthal, A. Brown

Purpose: Huntington's disease (HD) is a hereditary movement disorder associated with basal ganglia dysfunction. Involuntary movements (chorea) and postures (dystonia) can affect speech production and result in hyperkinetic dysarthria. Pharmacological treatments, such as vesicular monoamine transporter 2 (VMAT2) inhibitor, can reduce chorea in individuals with HD; however, their effects on speech remain poorly understood. In this pilot study, we seek to determine the effects of deutetrabenazine, an FDA-approved VMAT2 inhibitor, on speech function in patients with HD. Methods: Ten participants with HD will complete paragraph reading, sentence and syllable repetition tasks under two conditions: without medication (MED OFF) and with medication (MED ON). To evaluate the drug effects, we will use: 1) perceptual ratings of dysarthria severity and speech intelligibility based on paragraph readings tasks, 2) acoustic analysis to measure diadochokinetic rate (DDK) and sequential motion rate (SMR), and 3) lower lip and jaw kinematic measures (duration, range of motion, speed, trial-to-trial performance variability) based on ten sentence repetitions. Results: Data collection and analysis is underway. So far, 10 patients with HD completed the MED OFF visit and five patients also completed the MED ON visit. Preliminary findings of three patients showed: 1) mixed effects on perceptual ratings, 2) improved SMR but no changes in DDK performance, and 3) improved speech motor control as indexed by reduced trial-to-trial variability. Conclusion: Similar findings for the full data set would suggest positive effects of the drug on speech motor control that may not in all patients result in improved speech function.

Key Words: Huntington's disease; motor speech disorder; hyperkinetic dysarthria

Increased Local Gyrification Associated with Increased Autism Severity

J. S. Kim, E. S. Heller Murray, J. Segawa, A. Nieto-Castañón, D. S. Manoach, F. Isik Karahanoglu, H. Tager-Flusberg, F. H. Guenther, J. A. Tourville

People with Autism Spectrum Disorder (PwASD) exhibit significant heterogeneity in behavioral presentation. Previous literature found that PwASD experience a rapid increase of brain volume in the first few years of development, followed by an age-related decrease in these growth trajectories. The goal of the current study was to evaluate adolescents with a range of autism severities and linguistic abilities in the intermediate developmental stages to assess the relationship between brain morphometry and behaviors. Participants included 23 PwASD (11.8-21.1 years old; 15 M/8F) and 15 neurotypical controls (14.6-19.2 years old; 10M/5F) who underwent structural magnetic resonance imaging (MRI) scanning. Although there were no significant group differences in morphometric measures, the PwASD group demonstrated positive correlations between local gyrification index (LGI) and Autism Diagnostic Observation Schedule (ADOS) scores. LGI measures the ratio of cortex buried within cortical folds relative to the amount of cortex at each point along the cortical surface, which then provides an estimate of local cortical folding complexity. Speech network region of interest (ROI) analysis revealed positive correlations between LGI and Autism Diagnostic Interview (ADI-R) scores in five speech network clusters: bilateral superior frontal gyrus, left inferior parietal lobule and lateral occipital cortex, and right inferior temporal gyrus. Furthermore, there were significant negative correlations between LGI and number of different words per minute (NDW/M) in bilateral middle somatosensory cortex, and left middle motor and premotor cortex, parietal operculum, anterior supramarginal gyrus, and posterior inferior frontal sulcus. These findings suggest that increased LGI may be correlated with increased autism severity.

Key Words: autism, morphometry, neuroimaging

Cortical Dynamics Underlying Speech Sequence Planning

J. R. Liu, L. Zhao, P. W. Hullett, E. F. Chang

Speech production requires the planning and articulation of accurately sequenced speech sounds, though the neurological basis of how speech is sequenced is unknown. To address this, we used high-density electrocorticography to investigate the dynamics of neural activity while participants were cued to read, wait a short delay, and speak simple or complex syllable sequences (Bohland & Guenther 2006). While we found activity related to execution and feedback, we found unexpectedly prominent sustained activity across multiple cortical areas that lasted throughout all periods of the task. Sustained activity was found in the middle precentral gyrus (mPrCG), posterior superior temporal gyrus, supplementary motor area, supramarginal gyrus, and the inferior and middle frontal gyri. Sustained neural activity reflected distinct internal states that transition between the encoding, delay, pre-speech, and execution periods. Trial-averaged sustained population activity also showed distinct trajectories associated with each of these task phases. Encoding and execution period trajectories occupied roughly 2D planes, which were not parallel to each other, suggesting that activity prior to production does not directly trace the eventual neural trajectory associated with execution. Increased sequence complexity was associated with greater sustained activity, most prominently in the mPrCG. Pre-speech activity in the mPrCG also correlated with behavior, predicting single trial reaction times. These results suggest that speech production planning is dependent upon sustained cortical dynamics supporting speech sequence execution. Importantly, we identify the mPrCG as a novel and critical node of speech-motor planning.

Key Words: planning; sequencing; apraxia of speech

Auditory Feedback Control of Inter-Articulator Speech Coordination: Evidence From Jaw and Tongue Tip Movements

M. Masapollo, G. Oberle, K. Burge, A. Lebedeker, N. Salazar, K. Ferdowsiepour, A. Rodriguez, S. Nittrouer

In order to test whether and how immediate auditory feedback is involved in the coordinated action of sets of speech articulators, the current research quantified changes in the temporal and spatiotemporal relations between jaw and tongue tip movements in response to noise masking. Normal- hearing talkers recorded /tV#Cat/ utterances using electromagnetic articulography, with alternative V (/ɑ/-/ɛ) and C (/t/-/d/), across variation in production rate (fast-slow) and stress (first syllable stressed-unstressed). Approximately 240 utterances were produced in two conditions: normal listening and auditory feedback masking. Two kinematic measures were obtained: (1) timing of tongue-tip raising onset for medial C, relative to jaw opening-closing; (2) angle of tongue-tip raising onset, relative to the jaw phase plane. In the normal listening condition, any manipulation that shortened the jaw opening-closing cycle reduced both the relative timing and phase angle of tongue-tip movement onset. In the masking condition, specific changes were observed in how consistently the phase angle of tongue-tip movement onset scaled with jaw opening-closing across rate and stress variation, but not in the relative timing of tongue-tip movement onset. Collectively, these findings suggest that the spatiotemporal phasing between articulator movements relies more on immediate auditory feedback than the relative timing between ongoing articulator movements.

Key Words: speech motor coordination; auditory feedback control; electromagnetic articulography

Phonemic and Pitch Variability in Bilingual Preschoolers: A Comparison of Jamaican Creole and English

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Purpose: The purpose of this study was to investigate cross-linguistic effects and vocal development in bilingual preschoolers who speak Jamaican Creole (JC) and English.
Methods: Sixteen typically developing children (4 males, 12 females, M = 4 years; 4 months (4;4), SD = 0.3 years) completed the Diagnostic Evaluation of Articulation in Phonology Word Inconsistency Assessment subtest in JC and in English, with each child producing the same target word three times. Acoustic measures of voice onset time (VOT), VOT variability, mean fundamental frequency (fo), and fo variability were extracted from each target word. Mixed models were analyzed to understand the impact of language on each acoustic measure and regression models were analyzed to understand the relationship between phonemic and vocal variability.
Results: Statistical analyses revealed a significant interaction effect of vowel (/u, i/) and language on mean fo, in which vocal pitch was significantly different between vowels in English, but there was no difference between the vowels' pitch in JC. There was no impact of language on any other acoustic measure, nor a relationship between phonemic and vocal variability measures. Mean voiced VOT was longer than expected during productions of both languages.
Conclusion: Relatively longer voiced VOT is likely due to maturational effects on vocal and articulatory control in preschoolers. The difference in vowel pitch across languages may be due to intonational linguistic differences between JC and English. Longitudinal studies are needed to better understand phonemic and pitch maturation in bilingual children.

Key Words: Acoustics; Bilingualism; Vocal variability

Perceived Listening Effort for Individuals With Aphasia and Apraxia of Speech

K. Nealon, K. Stipancic, K. Nagle

Perceptual judgments of speech characteristics are often used during the assessment of individuals with aphasia and apraxia of speech (AOS) or dysarthria (Duffy, 2005). Although the identification of salient perceptual features is crucial for differential diagnosis and treatment planning, there is little guidance regarding how to account for the influence of listeners' subjective experiences on auditory-perceptual ratings (Kent, 1996). Perceived listening effort (PLE) has been used to investigate listeners' subjective effort when listening to individuals with neurogenerative diseases and patients following laryngectomy, but has not been examined for individuals with aphasia and comorbid motor speech impairment.
This pilot study investigates differences in PLE ratings from inexperienced listeners (N=10) compared to speech-language pathology (SLP) graduate students who have had courses in motor speech disorders and voice (N=10). Participants will listen to pseudo-randomly presented audio recordings of speakers with aphasia and comorbid apraxia and/or dysarthria. First, listeners will type what they hear (to obtain a measure of intelligibility), after which they will rate their PLE on a traditional visual analog scale. Group means for PLE and intelligibility will be compared, and measures of reliability will be calculated. Data collection is ongoing. We predict negative associations between PLE and intelligibility for both listener groups, but we expect that graduate SLP students will be more reliable. Clinically, PLE ratings may complement measures of intelligibility by providing the listener's perspective on communicative interactions with individuals with aphasia and concomitant motor speech disorders. PLE ratings from communication partners may serve as important measures of change.

Key Words: listening effort; intelligibility; apraxia

The Impact of Traditional Practices and Cultural Beliefs on the Diagnosis and Treatment of Tribal Communities' Speech Motor Disorders in Nilgiri Hills India

K. O. Babu

Objective: To investigate the impact of traditional practices and cultural beliefs on diagnosing and treating speech-motor control disorders in tribal communities.
Methods: A qualitative study was done among the Toda Tribal community in the Nilgiri Hills, using focus group discussions and in-depth interviews. Participants comprised people with speech-motor control problems, their caretakers, and traditional healers. Thematic analysis was used to examine the data.
Results: Traditional practices and cultural beliefs in tribal cultures were found to substantially impact the diagnosis and treatment of speech-motor control problems. Participants said that they relied on traditional healers to diagnose and treat speech motor control issues, frequently resulting in delayed or ineffective therapy. Traditional healers have also noted that spiritual and supernatural explanations for speech-motor control abnormalities have been used rather than biological ones.
Conclusion: Traditional practices and cultural beliefs play an important role in the diagnosis and treatment of speech-motor control problems in tribal cultures. These findings indicate the need for culturally appropriate interventions to enhance these groups' diagnosis and treatment of speech-motor control problems. The study proposes that healthcare providers evaluate the cultural beliefs and traditional practices of the communities they serve in order to deliver effective, culturally responsive care.

Key Words: Traditional Practices; Tribal Communities; Speech Motor Disorders; Nilgiri Hills India; Toda Tribes

Development of an Automated Relative Fundamental Frequency Analysis for Clinical Voice Evaluation

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The pattern of change in voice fundamental frequency during intervocalic syllables (VCVs) is a promising indicator of excessive laryngeal tension, a defining characteristic of hyperfunctional voice disorders (HVDs). However, current methods of identifying this pattern—called relative fundamental frequency (RFF)—require extensive manual analysis (>20 min/estimate) or the use of an algorithm called "aRFF-AP," which reduces analysis time but still relies on manual intervention to identify non-compliant signals and confirm VCV identification accuracy. Extensive analysis time and manual intervention serve as barriers to clinical implementation. Here, we detail the development of a fully automated RFF method that maintains accuracy whilst reducing analysis time.
Three repetitions of three VCVs (/afa/, /ifi/, /ufu/) were collected from 120 individuals with HVDs (65 female, 55 male; 52.6±18.8 years) and 120 age-/sex-matched controls. A two-stage random forest model and a series of rule-based processing methods were validated (200/40-speaker train/test split) for identifying VCVs and discerning non-compliant signals, respectively. RFF values from this Automated RFF Calculator, or "ARC," were evaluated for accuracy against aRFF-AP using paired t-tests. Pilot feedback regarding ARC usability was collected from a focus group of speech-language pathologists to guide future developments.
ARC achieved >90% accuracy for automated VCV and compliance detection relative to manual inspection. Average analysis time was reduced from 10.1±2.5 sec (aRFF-AP) to 2.5±1.1 sec (ARC). RFF values between the two algorithms were not significantly different. Future work will focus on improving the ARC user interface, as preliminary feedback cited long startup times and a lack of informative error messages.

Key Words: relative fundamental frequency; voice assessment; laryngeal tension

Effects of Dopaminergic Medication and Deep-Brain Stimulation on Disfluencies in Patients With Parkinson Disease

B. Rapp, S. E. Zauber, B. Walsh, S. Snyder, J. E. Huber

Disfluencies are a commonly reported speech symptom associated with Parkinson disease (PD), though the cause remains unknown. Studies have consistently reported that people with PD experience more disfluencies, particularly atypical disfluencies compared to healthy controls. One proposed theory, known as the dualistic model of dopamine levels and stuttering, posits that abnormally high or low levels of dopamine may cause an increase in disfluencies. The aim of the current study is to examine how levodopa medication and deep-brain stimulation affect fluency in people with PD. Twenty-seven participants with PD underwent testing before (on and off medicine) and six months after deep-brain stimulator implant surgery (optimally medicated, on and off stimulation). Participants were distributed across all three common PD motor subtypes (12 postural instability/gait, 7 tremor dominant, 8 intermediate). Participants read a passage aloud and provided a 2-minute monologue. Speech samples were transcribed. The number and duration of typical and atypical disfluencies were identified auditorily and using a wide-band spectrogram. After surgery, most participants reduced their levodopa equivalency dose. Results from the reading passage demonstrated no significant differences across time (pre-surgery, post-surgery) or condition (on/off medication/stimulation). In contrast to prior literature, participants produced more typical than atypical disfluencies. Monologue data analysis is nearing completion and will be included in the presentation. Future analyses will also examine how PD motor subtype affects results. Current results do not support the dualistic model of dopamine. However, future analyses including the monologue data will provide a stronger test.

Key Words: Parkinson disease, Disfluencies

The Effect of Alpha-Synuclein Aggregate Pathology on the Cranial Sensorimotor System in a Mouse Model of Parkinson's Disease

B. Rodgers, A. Schaser

Purpose: Voice deficits are common in Parkinson's disease (PD) and significantly impact quality of life. The goal of this study was to examine the effect of a potential underlying mechanism responsible for the complex voice deficits that exist in PD, aggregation of the protein alpha-synuclein.
Methods: An alpha-synuclein transgenic mouse model and fibril seeding approach were used in this study. Sixteen transgenic mice and 13 wild-type control mice were analyzed in this preliminary study. Mice of each genotype were assigned to either fibrillar or monomeric alpha-synuclein injection into the striatum. Baseline and post-injection acoustic measurements of rodent ultrasonic vocalizations were acquired.
Results: A genotype difference was found at baseline. Transgenic mice called significantly more than wild-type mice prior to injection [$t=3.506(27)$, $p = 0.0016$], indicating that overexpression of the human A53T mutation alone results in a change in vocal communication. Following injection, at the 2-month post-injection time point, all animals called significantly less than at baseline [$F(1,25) = 187.8$, $p = 0.0001$]. Analyses of objective vocalization characteristics, later timepoints, and additional injection sites and mice are ongoing.
Conclusions: Results depict the development of a mouse model that allows for manipulation of alpha-synuclein within discrete areas of the cranial sensorimotor system and enables the analysis of relevant vocalization behaviors. Results provide a critical foundational understanding of the role of aggregated alpha-synuclein in voice deficits in PD. Future work will continue to refine the mouse model to develop disease-modifying treatments to reduce or eliminate the burden of PD-specific voice disorders.

Key Words: Voice; Parkinson's disease; Animal models

A Comparison of Acoustic Measures and Perceptual Observations in Speech Samples From the Same Clinical Encounter

C. Rountrey, M. Mateja, N. McCarthy, A. K. Spotts

There is a need for objective acoustic measurement (OAM) of connected/spontaneous speech intelligibility (C/SSI) in clinical assessments of dysarthria to supplement clinicians' perceptual observations of intelligibility (POI). Clinicians tend to rely on POI in motor speech assessments (Gurevich & Scamihorn, 2017). OAM represents speaker voice/speech kinematics; POI is listener dependent. The relationship between OAM and POI is unknown. When clinicians perform OAM, they use short, elicited tasks. Elicited speaking tasks are rated as more intelligible than C/SSI (Johansson et al., 2022). Traditionally, C/SSI has been perceptually defined, and subject to familiarity and learning effects. POI has been correlated with OAM in elicited speaking tasks in highly controlled research settings, but not in C/SSI tasks in clinical settings.
We aim to compare POI to OAM of C/SSI in samples taken from the same clinical encounter for increased ecological validity.
Clinician-Research collaborations and a common voice/motor speech evaluation were established across an academic health center. Retrospective chart reviews include audio recordings of patients participating in elicited and C/SSI tasks. POI via visual analog scale (VAS) and narrative report (NR) and fundamental frequency interquartile range (F0-IQR) and vowel duration (VT) are variables of interest.
POI (VAS and NR), will be compared to OAM (VT and F0-IQR) from the same clinical encounter in C/SSI tasks. Given the established relationship in short, elicited tasks and highly controlled research settings, we hypothesize this relationship will also exist in clinical settings with C/SSI tasks. IRB approval was obtained on 2/13/23 for retrospective chart reviews (expected n≥30).

Key Words: acoustics, intelligibility, dysarthria

A Mixed Methods Study of Conversations in Natural Contexts: People With Parkinson's Disease and Healthy Volunteers

C. Rountrey, A. K. Spotts

Background: Literature focused on communication of people with Parkinson's Disease (PWPD) is limited with most qualitative work utilizing interviews (Baylor et al, 2011; Miller et al, 2006; Yorkston et al, 2017) or questionnaires (Jin et al, 2011; Miller et al, 2010; Wolff et al, 2019) with either PWPD or their caregivers.

This pilot study offers a new approach investigating differences between PWPD and healthy controls (HC) through analysis of syntax and semantics via recordings that were collected in the participants' natural environment. This offers insight into functional communication for PWPD.
Methods: Conversational audio samples were collected in clinical and home environments of PWPD and HC using LENA recorders (Ford et al, 2008). Time in the vicinity of conversation was measured. Each conversation was explored using inductive coding and followed Thematic Analysis (Braun & Clarke, 2006).
Results : Initial findings indicate that PWPD have a proportionately smaller time in the vicinity of conversation, have longer conversation times than HC, and differences exist in sentence purpose, initiating conversations and conversational topics.
Researchers are analyzing the larger sample to develop a poster presentation that visualizes the pilot results:

1. Compare time in the vicinity of conversation, PWPD vs. HC.
2. Analyze differences/similarities, PWPD vs. HC, in pattern of
    - conversational topics
    - pattern of sentence purpose
    - patterns of conversational initiation

We will discuss our findings and suggest strategies to improve conversation in natural contexts for PWPD. Future directions for investigating how motor speech disorders like Parkinson's Disease affect communication patterns quantitatively and qualitatively will be shared.

Key Words: conversation, parkinsons, mixed-methods

Preliminary Evidence for Motor- and Planning-Based Subtypes of Stuttering Based on Resting State Functional Connectivity Abnormalities

H. P. Rowe, J. A. Tourville, A. Nieto-Castanon, E. O. Garnett, H. Ming Chow, S. E. Chang, F. H. Guenther

The goal of this study was to test the GODIVA model-based hypothesis that adults who stutter (AWS) may comprise distinct motor- and planning-based subtypes that differ on whether stuttering arises in the cortico-basal ganglia motor loop or planning loop. We applied an unsupervised clustering technique to resting state functional connectivity (FC) measurements collected using functional magnetic resonance imaging (fMRI) from 93 AWS and 83 controls. FC was measured between all pairs of regions of interest (ROIs) within the motor loop and planning loop. A logistic regression using these connection strengths as predictors of group membership revealed a significant effect of the Right Cerebellum - Left Thalamus connection (part of the motor loop) and the Left Caudate - Left Pallidum connection (part of the planning loop). These connections were then used to investigate the presence of clusters within the AWS group using a k means clustering algorithm. Lastly, between-group comparisons (i.e., AWS versus controls) were conducted for each connection in each cluster, with the significance level corrected using a permutation test. Results revealed three clusters of AWS characterized by (1) no significant group differences between AWS and controls for either connection, (2) significantly reduced Left Caudate - Left Pallidum connectivity in AWS, and (3) significantly reduced Right Cerebellum - Left Thalamus connectivity in AWS. Overall, these findings suggest the presence of motor- and planning-based subtypes of persistent developmental stuttering. Future research will examine correlations between these potential subtypes and behavioral measures, such as stuttering type.

Key Words: stuttering; functional connectivity; subtypes

Motor Practice Stabilizes the Temporal Coordination of Articulatory Movements for Non-Native Onset Clusters

A. Shamsi, M. Masapollo, R. Meyer, R. Wayland

The widespread occurence of foreign-accented speech reflects, in part, the difficulty of producing speech sound sequences that are not present in one's native language. With respect to non-native onset consonant clusters, speakers have been shown to struggle with temporally coordinating the articulatory gestures affiliated with the successive consonants and the syllable nucleus. Here, we applied a motor sequence-learning paradigm to facilitate acquisition of these novel clusters. Native English-speaking participants repeatedly produced monosyllabic nonsense words containing non-native onset clusters (e.g., LBAT) over two consecutive days of motor practice, with two practice blocks in each test session. State-of-the-art electromagnetic articulography (EMA) was used to capture lingual, labial, and jaw motion during successive repetitions. For properly-sequenced cluster repetitions, analysis of the EMA sensor trajectories for each block across the two sequence-learning sessions showed: (i.) a general reduction in inter-gestural timing variability; (ii.) increased overlap between adjacent consonantal gestures; and (iii.) an increase in gestural overlap of the vowel-adjacent consonant and the vowel. Day 1 improvements in the consistency of motor performance were retained on day 2, indicating motor memory consolidation for the learned sequences. However, the data also indicated that the sonority distance between the segments of the cluster modulated changes in these timing relations, such that performance gains were larger in magnitude for onset clusters with larger sonority distances. Collectively, these findings demonstrate that extensive speech motor practice leads to greater efficiency and more native-like timing of articulator movements.

Key Words: speech motor sequence learning; consonant clusters; electromagnetic articulography

Detection of Pediatric Dysarthria: A Tech-Assisted Approach

A. Sims, E. Hatamimajoumerd, G. Alsebayel, M. Nasri, S. Ostadabbas, C. Harteveld, K. Allison

Early and accurate diagnosis of dysarthria is important for maximizing speech treatment outcomes for children with congenital dysarthria; however, objective diagnostic measures are currently lacking, leading to underdiagnosis. This presentation will provide an overview of the initial development stages of an app-based game aimed to leverage state-of-the-art computer vision algorithms to obtain kinematic measures of lip and jaw movement and improve objective diagnosis of dysarthria in preschool-aged children. This app is being developed by an interdisciplinary team through two parallel strands that will be discussed: 1) We will present preliminary data validating the accuracy of facial movement data derived from video frames using computer vision algorithms compared to "ground truth" 3D optical motion capture data. Our initial findings suggest that time courses of lip movements, estimated through facial landmarks, exhibit similar trends as their corresponding 3D optical motion. This provides a contact-less method for measuring facial movements and a computer-assisted tool for accurate diagnosis of dysarthria. 2) We will also describe our co-design process, in which our multidisciplinary team is leveraging game design approaches to create an age-appropriate enjoyable user experience (UX), while optimizing the accuracy of data acquisition within the game. This work is a first step towards translating the use of facial kinematic data to a clinically-usable tool for objective diagnosis of dysarthria in children.

Key Words: Dysarthria; diagnostic; tech-assisted approach

Speech Motor Instability During Spontaneous Speech in Parkinson's Disease

K. M. Smith, M. Demers-Peel, C. E. Stepp

Background: People with Parkinson's disease (PwPD) report worsening speech impairment with longer duration of speaking, but little research has been done to characterize this potential manifestation of motor instability. We assessed declines in acoustic features over the course of reading and picture description tasks in PwPD, and evaluated the impact of task type and participant characteristics.
Methods: We enrolled 44 PwPD at UMass Chan Medical School. Participants were categorized as no cognitive impairment (NC) or mild cognitive impairment (MCI). Speech tasks included the Rainbow passage and Cookie Theft picture description. First and last utterances were analyzed using Praat to obtain mean and SD fo, CPPS and LH ratio, and STSD was calculated. T-tests were used to compare first and last utterances within and between the tasks, in the overall cohort and by cognitive status.
Results: There were significant declines in mean fo , STSD, and CPPS in both tasks, and the magnitude of this decline was similar in both tasks. Comparing PD-NC and PD-MCI groups, these declines were not significantly different for either task, nor was the between-task difference significant. Declines did not correlate with motor severity.
Discussion:
Motor instability can be detected even in a brief speaking task in PwPD, whether the speech is standardized or spontaneously generated. The acoustic declines we observed were not associated with cognitive or motor status. This phenomenon may be a feature of PwPD even in earlier stages of neurodegeneration. Speech algorithms are less likely to be biased due to motor instability in PwPD.

Key Words: Parkinson's disease, acoustics, cognitive impairment

Computer-Assisted Analysis of Continuous Child Speech for Speech Disorder Detection

M. Speights, J. MacAuslan, S. Boyce

A common indicator of speech production disorders in children is a reduced ability to articulate complex syllables. Clinical studies of syllabic complexity have traditionally relied on phonetic transcription by trained listeners to characterize deviations in phonotactic structure. The labor-intensive nature of transcribing, segmenting, labeling, and hand-counting syllables has limited clinical analysis of large samples of continuous speech. In this study, we applied the SpeechMark® (SM) landmark analysis system to evaluate counts of syllabic clusters (syllable units) within 1952 continuous speech utterances spoken by 60 preschool children ages 3-5 years (n = 15 with speech disorder, n = 45 without speech disorder). The speakers were from two dialect regions, Midland and Southern. A generalized linear mixed effects negative binomial regression model was used to test the target response variable syllabic clusters per utterance (SC/Utt) by fixed factors of speech status, age groups and dialect, and with random factors of subjects and repeated segments. There was a significant main effect of speech status group reflecting that subjects without speech disorders had significantly more syllabic clusters per utterance than children with speech disorders. There was not a significant main effect for age however an interaction was found between age and speaker group status. Dialect did not have a significant main effect of syllabic clusters per utterance. We will discuss the use of computer-assisted methods for fast analysis of continuous child speech samples and implications for clinical practice.

Key Words: continuous speech, automated analysis, syllables, child speech

Variability of Speech Production Skills in 3-Year-Old With Autism, Language Delay, and Elevated Family Likelihood of Autism

C. Spencer, E. Rogers, C. Goldman, E. Roemer Britsch, J. M. Zuk, J. M. Iverson

Studies of speech motor control in children with autism spectrum disorder (ASD) are few1, but impairments such as an increased prevalence of speech sound distortions, residual errors,2,3, and motor speech delay4 have been reported. Language abilities5, 6 and familial risk7 may influence speech production in ASD, but the nature of the complex relationship among speech production, language, familial risk, and autism is yet unclear. To address this gap, we characterized speech production in children with elevated likelihood of developing ASD (EL; due to having an older sibling diagnosed with ASD) or typical likelihood (TL). EL children were further categorized according to diagnoses of language delay (EL+LD), autism (EL+ASD), or no diagnosis (EL+ND).
Methods: In a secondary analysis of existing data, we transcribed utterances of 48 three-year-old children during a 10-minute naturalistic play session with a parent at home. Recordings were analyzed for fully intelligible utterances, phonetic inventory, and variability of repeated word productions.
Results: Preliminary analyses of 8 children (TL n=5; EL+LD n=1; EL+ASD n=1; EL+ND n=1) indicate that TL and EL children are similar in number of fully intelligible utterances produced (TL 78-155; EL 73-152). Children in the EL groups generally showed increased variability on repeated word productions (variability index = 2.14-3.67), as compared to the TL group (variability index = 0.11-2.38). The EL+ASD participant showed the highest variability index (3.67) and the fewest number of initial (n=7) and final consonants (n=3).

Key Words: autism; speech; preschool

Tipping the Scales: Indiscriminate Use of Conventional Scales to Rate Diverse Dysarthric Features

K. L. Stipancic, B. M. Whelan, Y. Zhao, M. Kuruvilla-Dugdale

The minimally detectable change (MDC) has been widely used across the rehabilitation science field for identifying the magnitude of change in an outcome measure that is not due to chance/random error and thus, can be considered real and potentially clinically meaningful. MDC estimates are critical for accurate interpretation of changes due to intervention and disease progression. The MDC has recently been applied to speech outcome measures such as intelligibility and speaking rate. Although scaled ratings of auditory-perceptual speech features are ubiquitous in both clinical and research settings, our field lacks estimates of detectable change for ratings of this kind. This study aimed to calculate MDCs of four features (i.e., overall speech impairment, articulatory imprecision, monotony, and slow rate) rated by non-expert listeners using visual analog scales (VAS). Twenty-two listeners rated samples from speakers with amyotrophic lateral sclerosis (ALS), speakers with Parkinson's disease (PD), and neurologically healthy speakers using separate scales for each of the four features. Test-retest reliability was calculated using Pearson correlations and MDCs were calculated using a standard formula (MDC95 = 1.96*▪ 2*SEM) separately for each of the four features and each speaker group (i.e., ALS, PD, controls). Across features, MDCs were smallest for the control group, followed by the PD group, and were largest for the ALS group. Overall, MDCs ranged from 14.62 (overall severity for the control group) to 53.29 (monotony for the ALS group). Given the high magnitude of MDCs, findings of this work could motivate future endeavors to improve the reliability of scaled ratings.

Key Words: dysarthria; perception; measurement

Minimally Detectable Change of Visual Analog Scale Speech Ratings in Dysarthria: Severity, Imprecision, Monotony, and Rate

K. L. Stipancic, Y. Zhao, L. Pinkerton, M. Kuruvilla-Dugdale

Various scaling methods [e.g., equal-appearing interval (EAI) and direct magnitude estimation (DME) scales], are used to rate overall and feature-specific severity for speakers with dysarthria. Of the conventional scales, EAI is widely used regardless of whether it is a good fit for the perceptual dimension of interest. Certain dimensions (e.g., prothetic ones) cannot be divided into equal intervals and should be rated using DME or a similar scale that is appropriate for both prothetic and metathetic dimensions. Improper scale selection introduces error into perceptual judgments and negatively affects diagnosis, progression monitoring, and treatment tracking. This study sought to determine the validity of rating perceptual dimensions salient to hypokinetic dysarthria using a 5-point EAI scale against DME scaling. Twenty listeners rated a randomized order of 164 speech samples from individuals with Parkinson's disease and neurologically healthy controls over two sessions spaced one week apart. For each session, either an EAI scale or a DME scale (order randomized) was used. Listeners rated five features, i.e., reduced loudness, articulatory imprecision, short rushes of speech, monotony, and overall speech severity. Arithmetic means of EAI scores were plotted against the geometric means of DME scores for all speech samples. The linear relationship between the two sets of scores for monotony suggests that an EAI scale is a good fit for this dimension. The non-linear relationship for reduced loudness, imprecision, short rushes, and overall severity suggests that DME is appropriate for rating these features. Implications of applying the incorrect scale to perceptual features will be emphasized.

Key Words: dysarthria; perception; measurement

Characterizing Speech Motor Control Impacts in Frontotemporal Dementia

B. Tracey, M. Zhao, K. Placek, Y. Gong, M. Vilela, J. Glass, A. Brodtmann, A. Vogel

Speech analysis has emerged as a powerful tool for characterizing progression of neurodegenerative disease and is particularly relevant to frontotemporal dementia, which is known to cause speech motor control deficits as well as linguistic deficits. Typically, acoustic features are extracted capturing variability in pitch, amplitude and timing, and linguistic features are extracted including parts of speech analysis and measures of sentence complexity. Here we focus on acoustic signatures of motor speech control from speech samples collected at the University of Melbourne consisting

of 55 FTD subjects (33 behavioral variant, 11 semantic variant, and 11 nonfluent variant) and 107 healthy elderly subjects. Subjects were recorded performing monologue, diadochokinetic (pataka), and sustained vowel phonation tasks. Because the dataset contains limited longitudinal data, we seek to discover which speech features are most sensitive to disease by extracting feature importance ranking from classifiers trained to discriminate patient groups. In addition to widely-studied timing and pause measures, our results show that measures of vocal clarity are important cues for discriminating patient groups. We additionally explore the differential effects of FTD on various speech endpoints in men and women, demonstrating that signatures of disease appear more sensitive to sex in sustained phonation tasks than in other tasks. Our long-term goal is to characterize these candidate speech endpoints in longitudinal studies to determine which are suited to tracking disease progression in clinical trials.

Key Words: FTD, dementia

21st Century Motor Phonetics: Evidence for the Discrete, Gated, Pulsatile Nature of Speech Motor Control

A. Wrench

A radical new theory of speech production is introduced. Evidence recorded from simultaneously acquired lingual, lip and glottal data streams reveals that sets of motor commands are issued at regular ~100ms intervals. Each set of motor commands defines a transition to point in articulatory and auditory sensory space associated with the intended phoneme. The duration of this transition can be specified to take one or two intervals. Most often the following transition is initiated at the instant that the preceding transition reaches its target but sometimes, to satisfy prosodic stress, the same set of motor commands will be repeated for one or more cycles. It is proposed that these motor commands to all articulators are gated by pulsing neurons in the thalamus and/or subthreshold oscillations of olivary neurons in the cerebellum. These commands consist of an initial feedforward gated pulsatile signal to pools of motor neurons to contract their associated neuromuscular compartment to a specified length. This is followed ~100ms later by a planned feedforward adjustment command combined, if necessary, with a corrective feedback command. Motor commands are observed to be issued sequentially for each articulatory/auditory target in turn. The mapping between articulatory set of commands and the expected auditory target is thought to be held in the cerebellum. Any error in the expected mapping results in an error signal from the cerebellum to correct the motor commands at the next gating interval. Examples of speech are presented showing motor control patterns and the emergent "segmental" acoustic signal they produce.

Key Words: discrete; pulsatile; speech motor control

The Effects of Focal Attention on Speech Auditory Feedback Error Detection and Motor Control

Y. Zhang, K. Sarmukadam, R. Behroozmand

Objective: The present study used a novel altered auditory feedback (AAF) paradigm to investigate how attentional mechanisms affect speech auditory feedback error detection and motor control.
Method: Electroencephalography (EEG) and speech data were collected from 21 neurologically intact subjects with no history of speech and hearing disorders (12 females, mean age: 62 yrs.) while they produced the speech vowel /a/ and received randomized ±100 cents pitch-shift stimuli in their auditory feedback. Subjects were instructed to attend to the auditory feedback and press a button to indicate whether they detected a pitch-shift stimulus. Data from this group was compared with data from 22 subjects (15 females, mean age: 64 yrs.) who completed the same AAF task without attentional instruction.
Results: We found smaller magnitudes of speech compensation in the attention vs. no-attention group and a significant positive linear association between speech compensation magnitude and P2 event-related potential (ERP) amplitude. Our

data also revealed a significantly enhanced P2 ERP amplitude for the attention group. Source localization analysis showed significantly stronger neural activities in the attention group in areas within the insula, precentral, and postcentral gyrus. Conclusion and Significance: These findings suggest that focal attention can enhance auditory error detection mechanisms and result in generating more stable speech output (i.e. smaller compensation) in response to feedback pitch alterations via modulating the auditory feedback gain for speech error control. Our results inform the theoretical models and pave the way toward advancing clinical approaches for targeted diagnosis and treatment of speech motor disorders.

Key Words: altered auditory feedback; speech motor control; sensorimotor integration